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Commercially Valuable Shellfish on Leased
Portions of Elizabeth River Bottom
Near the New West Norfolk Bridge.

--State Project--
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by

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ABSTRACT

Sampling for oysters and clams conducted in
June of 1979 indicated that oysters were present in
several places in densities which would support commercial
harvest. It is noted, however, that the area is presently
classed as condemned by the Virginia Department of Health.

Hard clams and soft clams were present in very
low numbers.

Quantities of oysters recovered in 1979 were often
several times larger than those observed when the same areas
were sampled in 1974, before construction of the bridge.
Natural recruitment is indicated as the source of the
increased quantities. On the basis of our data, there
are no indications of any adverse impact from the bridge
construction could be inferred.

Values of oysters and shell on the leases in
June of 1979 have been estimated.

INTRODUCTION

Background

A study of several plots of bottom in the Western branch of the Elizabeth River in the vicinity of the new West Norfolk Bridge was done in June 1979 by the Virginia Institute of Marine Science at the request of the Virginia Department of Highways and Transportation at Suffolk, Virginia. The study was performed shortly after completion of the new span across the river. The study had several purposes: 1) to describe the magnitude of the shellfish and shell material on the leases; 2) to determine if the construction had any adverse effect on surrounding shellfish populations; and, 3) to determine the dollar value of the shell and oysters in the right-of-way areas.

The current study compares the 1979 data to similar data collected in January 1974 (prior to construction of the new bridge). The former study, dated 20 January 1974, is entitled, "A Survey in the Elizabeth River for Oysters and Clams in the Vicinity of the Site of the New West Norfolk Bridge" and was submitted to the Department of Highways and Transportation. Data present in that report are summarized here.

Ecological Aspects of the Area of Study

The area studied is located in the Western Branch
of the Elizabeth River a mile upstream from the junction
with the main body of the river. The shores of the Elizabeth
River and, to a lesser extent the Western Branch, are crowded
with manufacturing, transportation, commercial, residental
and municipal activities. As a waterway, the river experiences
heavy vessel traffic ranging from ocean-going Navy and merchant
ships to small pleasure craft. Because of these activities
and others, the Virginia Department of Health has
condemned the Elizabeth River and restricted the harvest
of shellfish. This restriction limits the harvesting of
shellfish in the Elizabeth River to one period in the summer
and requires that such oysters as are harvested be relaid
in an area of clean water for a minimum of 15 days under
strict State supervision before they can be sent to market.

Water conditions (such as salinity and dissolved
oxygen) are sufficient for the natural reproduction and
growth of clams and oysters. In the early part of the
century there was much oystering in the Elizabeth River;
however, since mid-century oystering activity has been low
or nonexistant.

Two oyster diseases MSX (<u>Minchinia</u> <u>nelsoni</u>) and
Dermo (<u>Perkinsis</u> <u>marinum</u>) are active in the Elizabeth
River. MSX entered Chesapeake Bay in 1960 and still makes

the planting of James River seed oysters economically
impractical in this area. However, oysters originating
as a natural set in this area acquire some natural resistance
to this disease.

Dermo, however, may still kill up to 25% of the
oysters in areas such as the Elizabeth River, if proper
management methods are not observed.

METHODS AND MATERIALS

Sampling in 1979 followed the same plan that
was used in 1974. The areas studied were first gridded
into 250 foot squares; later, samples were taken near the
center of each. Figure 1 shows the areas studied, the
outlines of the leased plots and location of the squares
or stations sampled. Table 1 lists the number of acres
of each lease in the study area, and the number of locations
sampled in each.

The corners of all the oyster ground leases were
marked with stakes by a Virginia Marine Resources Commission
surveyor. Stakes and buoys were placed at grid reference
points by VIMS personnel with the aid of a floating measuring
line.

At each station samples of the material on and
up to four inches into the bottom were collected with
commercial patent tongs. When the tongs were retrieved

they closed together so that they retained all solid matter which was more than about one inch in diameter; some smaller material was also retained. One grab of the tongs was equivalent to one sample.

Material brought up by the tongs was examined to note bottom type, vegetation and types of organisms present. For oysters the following data were recorded: numbers of living large oysters (3 inches and over in length, i.e. commercial-sized); small oysters (less than 3 inches); number of spat (oysters which set in 1978); number of boxes (a box is a shell which is empty of meat but whose two valves are still joined by the hinge); volume of large and small live oysters; volume of shell which had been resting on the surface; and volume of shell which was buried in the bottom. Oysters at all stations were classed as market-sized (3 inches or larger); small oysters (less than 3 inches); and spat (1978 set).

Numbers of live clams and clam boxes were recorded.

From observed numbers and volumes, estimates of densities and quantities of oysters and shell were calculated for each lease and for the portion of each lease covered by the right-of-way for the new bridge. Factors and methods used in our calculations are shown in Table 2.

Data obtained in 1979 are compared with that obtained in 1974 to show changes. Figures for 1974 were

recalculated from the raw data in order to fit the slightly revised format used in this report and because of adjustments in the following two factors: area covered by the tongs at each station in 1974 was 2.4 yd^2 vice 2.0; and, for shell, 50 quarts per Virginia bushel is used here vice 52. In all comparisons similar stations are compared. Factors and methods used in our calculations are shown in Table 2.

In the following report detailed tabulations appear in the Appendix; summaries appear with the text.

The results for 1979 will be presented in relation to the leases and to the right-of-way areas which are shown in Figure 1.

RESULTS AND DISCUSSION

Lease of J. H. Miles & Co. - 31.74 Acres

Most of this lease lay upriver of the new bridge, but the downriver edge was crossed by the bridge (Figure 1). On this lease a total of 37 samples were taken at 28 stations (Table 1).

Outside the Right-of-Way - 1979

In 1979 twenty-three stations were occupied in this area. Live oysters were found at 18 locations, where oyster density ranged from 0 to 25.0/yd^2 (Appendix, Table A).

The average density for all stations was 7.8/yd^2 or 88 bu/
acre (Table 3). Sixty-six percent of the oysters were less
than three inches long which indicates that substantial
recruitment had occurred during the past year or two (Appendix,
Table A).

Shell material was moderately abundant, with an
estimated average density of 760 bu/acre; 59% was classed
as surface shell (Table 4). Mortalities based on box counts
were 38%, which is moderate to high for this area (Table 3).
Six spat were observed (Appendix, Table A).

Inside the Right-of-Way - 1979

The right-of-way associated with the new bridge
was calculated by the Virginia Department of Highways and
Transportation to be 1.96 acres. Five stations were occupied
here and the average oyster density was 8.5/yd^2 or 95 bu/
acre (Table 3). The bottom was firm at all stations and
10 spat (set in 1978) were observed (Appendix, Table A).

Shell density was moderate and averaged 804 bu/
acre; 79% of this was surface shell (Table 4). Mortalities
were moderate to high (33%) which was essentially the same
as that noted outside the right-of-way (Table 3).

Changes Since 1974

Details of the 1974 sampling are shown in the
Appendix, Table B. There was a major increase in oyster
density on this lease since 1974.

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In 1974 in the right-of-way, the average oyster density was 43 bu/acre, whereas in 1979 it was 95 bu/acre. Outside the right-of-way oyster density went from 36 bu/acre to 88 bu/acre (Table 3).

Total shell recovered from the whole lease increased from an average of 569 bu/acre in 1974 to 771 bu/acre in 1979; surface shell comprised, respectively, 44% and 64% of these values (Table 4).

Mortalities for Miles' lease went from 24% to 36% in the 1974-79 period (Table 3). Both values are considered moderate to high.

Summary - Miles' Lease

There is no evidence based on our data which suggests that construction activities have had any adverse impact in this area. Surface shell is more abundant now than previously; also, more oysters (more than double) are present now than formerly. Mortalities as shown by box counts were moderate in 1974 and slightly higher in 1979. The reason for this increase is not apparent; higher mortalities may have been caused by MSX or Dermo, but other factors such as pollution, etc., can not be ruled out. The clam resource was negligible in both years, (i.e. No live hard clams, two hard clam boxes and two live soft clams (each about one inch long) were observed in 1979; one live soft clam was seen in 1974.)

Lease of T. H. Conklin - 16 Acres

Outside the Right-of-Way - 1979

In 1979 fourteen stations were occupied on Conklin's lease in the area outside of the right-of-way. Live oysters were found at only five of these locations (Appendix, Table C).

The average density ($1.3/yd^2$ or 16 bu/acre) was very low. A substantial number of the oysters (74%) were less than three inches. This indicated significant recruitment had occurred during the past two years. Shell material was scant (294 bu/acre), and 54% was surface shell. The box count (42%) was moderate to high (Tables 3 and 4).

Inside the Right-of-Way - 1979

Two stations were occupied in the 1.43 acres covered by the right-of-way (Appendix, Table C).

Similar to the preceding area, oyster density was very low $3.2/yd^2$ or 39 bu/acre. One spat was observed and mortality (box count) was moderate to high at 37% (Table 3). Shell was more abundant in this area than outside the right-of-way (5.4 qts/yd^2 or 521 bu/acre). Thirty-eight percent of the shell was surface shell (Table 4).

Changes Since 1974

Details of the 1974 data are shown in the Appendix, Table D.

The condition of this lease improved between the two studies. For example, in 1974 in the right-of-way, oyster density was very low at only 2 bu/acre; by 1979 it was 39 bu/acre. Outside the right-of-way oyster density showed a smaller increase: 12 bu/acre in 1974 and 16 bu/acre in 1979 (Table 3).

Shell materials on this lease were sparse in all areas. From the entire lease 154 bu/acre were recovered in 1974, and 108% more (321 bu/acre) in 1979. A major aspect was that surface shell made up a larger percentage of the catch in 1979 (51%) than it did in 1974 (28%), (Table 4).

Summary - Conklin's Lease

On this area overall, which was entirely soft mud, a little improvement in the oyster resource was seen. Nothing was seen which suggested that construction had had an adverse impact. Mortalities in 1979 were moderate to high which was higher than in 1974; these data, however, are based on limited numbers of oysters. No hard or soft clams were seen in 1974 or in 1979.

Lease of Robert MacMillan - Lease A

A small portion (0.63 acre) of this plot lies in the bridge right-of-way. The bulk of the plot is below

the bridge (Figure 1). On this 13.2 acre lease 27 samples
were taken at 12 stations (Table 1).

Outside the Right-of-Way- 1979

Live oysters were found at all of the 11 stations
sampled, and their density ranged from $4.4/yd^2$ to $40.7/yd^2$
(Appendix, Table E). The average oyster density was 17.5/
yd^2 or 278 bu/acre (Table 3). This density is considered
to be high and sufficient to support commercial harvest.
Mortalities were moderate (26%), (Table 3). Recruitment
during the past year or two has been good since 71% of
the oysters were less than three inches long. Also, numerous
spat (49) were found in this area.

Shell was also abundant, and the average density
was 9.3 qts/yd^2 or 904 bu/acre; 70% of this shell was
surface shell (Table 4).

Inside the Right-of-Way- 1979

In 1979 two samples were collected at a single
station in this small area. The average oyster density
was estimated at $27.0/yd^2$ or 430 bu/acre which is regarded
as high. Mortalities based on box counts were moderate
(29%), (Table 3). Recruitment has been good in this area
since 12 spat were seen and 86% of the oysters were less
than three inches long.

Shell density was high at 8.9 qts/yd^2 or 859 bu/acre (Table 4).

Changes Since 1974

Details of sampling in 1974 are shown in Appendix F. This area showed a similar increase in density as outlined for other leases in the area.

Inside the right-of-way oyster density went from 30 bu/acre to 430 bu/acre in the 1974 to 1979 period. Shells obtained during sampling increased from 403 bu/acre to 859 bu/acre over the same period. Mortalities which were moderate in 1974 (33%) were essentially the same in 1979 (29%), (Tables 3 and 4).

Outside the right-of-way conditions had improved over the 1974 to 1979 period. Oyster density went from 32 bu/acre to 278 bu/acre over the same period. Shells recovered increased from 565 bu/acre in 1974 to 904 bu/acre in 1979; the percentage of surface shells increased from 44% in 1974 to 70% in 1979. Mortality was moderate (24% and 26%) in both years (Tables 3 and 4).

Summary - MacMillan's Lease A

There is no evidence based on our study which suggests that construction has had any adverse impact of this lease. The increase in oysters between 1974 and 1979 was much greater than that on any other area studied (except for lease B and Baylor Bottom). The clam resource was negligible in both years.

Lease of Robert MacMillan - Lease B

There was no right-of-way area in this lease. This plot was adjacent to and downstream of Plot A. Here 42 samples were taken at 15 stations.

Oysters were found at 9 stations, all of which were on the channel side of the plot. On the near shore portion where six stations were sampled, mud was found at all but one station (Table E, Appendix).

Oyster density ranged from 0 to $29.8/yd^2$ with an average density of $6.1/yd^2$ or 66 bu/acre (Table 3). Recruitment has apparently been adequate during the past year or two since 69% of these oysters were less than three inches long. Mortalities were moderate (24%) (Table 3).

Shell material was scarce in this lease with an average density of only 183 bu/acre; about 52% of this was surface shell (Table 4).

Changes Since 1974

Details of the 1974 sampling are shown in Appendix, Table F. There was an increase in oyster density during the 1974 to 1979 period from 8 bu/acre to 66 bu/acre. Shells recovered increased from 101 bu/acre in 1974 to 183 bu/acre in 1979; in both years approximately half were surface shells. The percent mortality increased slightly from 19% in 1974 to 24% in 1979 (Tables 3 and 4).

Summary - MacMillan's Lease B

No adverse impact was indicated by our data.
Clams were negligible in both years.

Lease of Robert MacMillan - Lease C

Nineteen samples were taken with patent tongs
at seven stations (Table 1) and a total of 39 live oysters
were collected (Appendix, Table E).

The average density was low at $1.6/yd^2$ or 20 bu/
acre. Recruitment had been satisfactory over the past
year or two since 64% of these oysters were less than three
inches long. Moreover, five spat were observed. Mortalities
were estimated at 33% which is moderate. Shells were scarce
and density was 47 bu/acre. Most of this was buried (85%).

Changes Since 1974

There was a slight decrease in oyster density
since 1974 (Appendix, Table F). Density in 1974 was 34
bu/acre and in 1979 it was 20 bu/acre. Shells went from
235 bu/acre in 1974 to only 47 bu/acre in 1979; both of
these values show low densities. Surface shells were
less (15%) in 1979 compared to 1974 (36%), (Tables 3
and 4).

Summary - MacMillan's Lease C

Densities of oysters and shells were low in 1974 and lower in 1979. There is no evidence that this decrease was due to construction activity. It is probable, however, that it was due to natural causes. Our reasons follow:

1. Lease C is farther from construction activities than any other lease studied;

2. On two areas (leases A & B) between this lease and the new bridge there were increases in both oysters and shells. Moreover, on these two leases there were increases in the percentage of surface shell from 1974 to 1979 indicating that there had been no deposition of sediment; and

3. On the Baylor Bottoms adjacent to Lease C there was no change in shell density or percentage of surface shell; oyster density increased.

Clams were scarce in 1974; none were seen in 1979.

Baylor Bottom

An area of Baylor Bottom adjacent to the bridge was also sampled (Figure 1). It is situated between MacMillan's lease C and the main channel of the river.

Oyster density in this area averaged 8.2/yd^2
or 99 bu/acre (Table 3 and Appendix, Table G). Recruitment
was good over the past year or two since 53% of the oysters
were less than three inches long and sixteen spat were
observed. Mortalities as indicated by box counts were low
to moderate (16%). Shell density was low and averaged
only 172 bu/acre; 41% was surface shell (Table 4).

Changes Since 1974

There has been an improvement in oyster density
in this area since 1974. It was only 11 bu/acre in 1974
(Appendix, Table H), but by 1979 had increased to 99 bu/acre.
Mortalities were about the same; 21% in 1974 and 16% in 1979.

Shells were about the same in both years: 179
bu/acre in 1974 and 172 bu/acre in 1979. The percentage
of surface shell, however, remained about the same: 45% in
1974 and 41% in 1979 (Tables 3 and 4).

Summary - Baylor Bottoms

These Baylor Bottoms showed an increase in oyster
density similar to adjacent leased bottoms in the 1974 to
1979 period. Shell density and percent surface shell showed
no change. Therefore, our evaluation is the same as for
the leased bottoms. That is, there is no evidence from our
data that construction activity had any adverse impact on
these bottoms. No clams were seen in either year.

SUMMARY

Value of Oysters and Shells on the Various Leases

Densities in bushels per acre and quantities of oysters and shells estimated to be on leased grounds are summarized in Tables 3 and 4. The values of the above-mentioned oysters and shell in the right-of-way are shown in Table 5. The estimated values are based on our findings that oysters from West Norfolk Bridge are typically of good quality, and that market-sized oysters might sell for as high as $12.00 per bushel and the small oysters may be valued at $5.00 (if they come from non-condemned areas). These prices, however, have been reduced in our value calculations by 30% since the study area is classed as condemned and oysters must be relaid prior to sale. This practice, of course, is expensive and it adds to their sale price.

Shells were valued at 32¢ a bushel which is the "planted" value.

Outside the Right-of-Way

Estimated densities in bushels per acre and quantities of oysters and shells estimated to be on leased areas outside the right-of-way are summarized in Tables 3 and 4. One area, MacMillan's upriver lease, had a high density of oysters (278 bu/acre). Miles' lease and Mac Millan's lease B had moderate densities as did the area of

Baylor Ground which was sampled. On Conklin's lease and on MacMillan's lease C oysters were sparse.

In the Right-of-Way

Area 1 - J. H. Miles & Co. (1.96 acres)

Here oysters were found in a moderate density. On 1.96 acres there were an estimated 187 bushels of large and small oysters and 1,575 bushels of shell. Total value was estimated as $1,447.60 (Table 5).

Area 2 - T. H. Conklin (1.43 acres)

Oysters were sparse (56 bushels) and shell was low (744 bushels) on this 1.43 acre area. The combined value of oysters and shell were estimated as $571.28.

Area 3-A - R. R. MacMillan (0.63 acres)

Oyster density here was very high (430 bu/acre). Shell was plentiful (859 bu/acre) on the 0.63 acre area. The estimated value of oysters and shell was $1,391.12.

Table 1

Leases, on Which Sampling Was Conducted in the
Vicinity of the West Norfolk Bridge in the
Elizabeth River - June 1979.

Lessee's Name	Acreage in Lease	Area Studied (Acres)	Number of Stations	Number of Samples
J. H. Miles & Co.	51.10	31.74	28	37
T. H. Conklin	16.00	16.00	16	24
R. R. MacMillan - A	13.20	13.20	12	27
R. R. MacMillan - B	15.70	15.70	15	42
R. R. MacMillan - C	7.20	7.20	7	19
Baylor Ground	--	10.41	7	24

Table 2 (Contd.)

$$\text{Density} \times \frac{4{,}840\ \text{yd}^2}{\text{acre}} \div \left(\frac{\text{Number of oysters}}{\text{bushel}}\ \text{or}\ \frac{50\ \text{qts shell}}{\text{bushel}}\right)$$

X Acreage of area studied = estimated quantity on area

For example, using data from Miles' lease for illustration:

8.0 oys/yd^2 X 4840 yd^2/acre $\div$ 430 oys/bu X 31.74 acres =

2,858 bushels oysters, and

8.0 qts shell/yd^2 X 4840 yd^2/acre $\div$ 50 qts/bu X

31.74 acres = 24,579 bushels shell

[1]Based on sampling.

[2]Based on sampling and adjusted to agree with total count.

[3]Assumed..

Table 3

Estimated Quantities of Oysters on Leases in the Elizabeth River Near the New West Norfolk Bridge Based on Sampling Conducted January 1974 and June 1979.

Tract	AREA (acres)	LARGE AND SMALL OYSTERS						SPAT		Percent Mortality	
		Average Density (Number/sq yd)		Average Density (VA bu/acre)		Estimated Quantity (VA bu)		Average Density (Number/sq yd)			
		1974	1979	1974	1979	1974	1979	1974	1979	1974	1979
Miles											
Entire lease	31.74	3.1	8.0	37	90	1,177	2,849	0.0	0.3	24	36
Right-of-Way	1.96	3.6	8.5	43	95	85	187	0.0	0.9	28	33
Outside R/W	29.78	3.0	7.8	36	88	1,092	2,662	0.0	0.2	23	38
Conklin											
Entire lease	16.00	0.9	1.5	11	19	176	299	0.0	0.3	24	41
Right-of-Way	1.43	0.2	3.2	2	39	4	56	0.0	0.3	0	37
Outside R/W	14.57	1.0	1.3	12	16	172	243	0.0	0.3	24	42
MacMillan, A											
Entire lease	13.20	2.7	18.2	32	289	427	3,820	0.0	1.8	24	26
Right-of-Way	0.63	2.5	27.0	30	430	19	271	0.0	4.8	33	29
Outside R/W	12.57	2.7	17.5	32	278	408	3,499	0.0	1.6	24	26
MacMillan, B	15.70	0.6	6.1[1] 5.5[2]	8	66[1] 60[2]	122	1,038 938[2]	0.0 0.0	0.4[1] 0.3[2]	19	24[1] 26[2]
MacMillan, C	7.20	2.8	1.6	34	20	242	144	0.0	0.2	20	33
Baylor, below bridge	10.41	0.9[3] 0.6[4]	8.2	11[3] 8[4]	99	112[3] 79[4]	1,031	0.0[3] 0.0[4]	0.5	21[3] 25[4]	16

1. Data for only those 1979 samples which were also done in 1974.
2. Data for all samples taken in 1979.
3. Data for only those stations which were done in 1979.
4. Data for all samples taken in 1974.

Table 4

Estimated Quantities of Shell on Several Tracts in the Elizabeth River, Near the New West Norfolk Bridge
Based on Sampling Conducted January 1974 and June 1979.

Tract	AREA (acres)	SURFACE SHELL				BURIED SHELL				TOTAL SHELL		Percent of Surface Shell	
		Density (bu/ac)		Quantity (bu)		Density (bu/ac)		Quantity (bu)		Quantity (VA bushels)			
		1974	1979	1974	1979	1974	1979	1974	1979	1974	1979	1974	1979
Miles													
Entire lease	31.74	252	494	8,010	15,697	317	277	10,049	8,782	18,059	24,479	44	64
Right-of-Way	1.96	405	638	794	1,250	281	166	550	325	1,344	1,575	59	79
Outside R/W	29.78	219	448	7,216	14,447	324	312	9,499	8,457	16,715	22,904	40	59
Conklin													
Entire lease	16.00	43	165	686	2,640	111	156	1,775	2,505	2,461	5,145	28	51
Right-of-Way	1.43	91	198	130	283	91	323	130	461	260	744	50	38
Outside R/W	14.57	36	161	556	2,357	114	133	1,645	2,044	2,201	4,401	26	54
MacMillan, A													
Entire lease	13.20	237	642	3,132	8,471	314	258	4,144	3,410	7,276	11,881	43	71
Right-of-Way	0.63	109	816	69	514	294	43	185	27	254	541	27	95
Outside R/W	12.57	249	628	3,063	7,957	316	276	3,959	3,383	7,022	11,340	44	70
MacMillan, B	15.70	48	96^1 97^2	760	$1,504^1$ $1,526^2$	53	87^1 103^2	835	$1,367^1$ $1,625^2$	1,595	$2,871^1$ $3,151^2$	48	52^1 48^2
MacMillan, C	7.20	85	7	613	50	150	40	1,081	287	1,694	337	36	15
Baylor, below bridge	10.41	81^3 57^4	70	840^3 596^4	731	98^3 89^4	102	$1,020^3$ 928^4	1,061	$1,860^3$ $1,524^4$	1,792	45^3 39^4	41

1. Data for only those 1979 samples which were also done in 1974.
2. Data for all samples done in 1979.
3. Data for only those stations which were done in 1979.
4. Data from all samples done in 1974.

Table 5

Estimated Values[1] of Current (June 1979) Quantities
of Oysters and Shell on Various Areas of Leased
Ground Within the Right-of-Way of the New West
Norfolk Bridge, Western Branch of the Elizabeth
River.

Lease:

  Miles

Acreage[2]	1.96	
Value of Large Oysters		495.60
Value of Small Oysters		448.00
Value of Shell		504.00
TOTAL		$1,447.60

  Conklin

Acreage[2]	1.43	
Value of Large Oysters		235.20
Value of Small Oysters		98.00
Value of Shell		238.08
TOTAL		$ 571.28

  MacMillan

Acreage[2]	0.63	
Value of Large Oysters		462.00
Value of Small Oysters		756.00
Value of Shell		173.12
TOTAL		$1,391.12

1. Calculation of value was based on the following prices:
    for large oysters (3 inches or longer) oysters $12/bu is
    a reasonable price for good quality oysters; for smaller
    oysters, $5/bu; and for shells, 32¢/bu. The prices for
    oysters have been reduced by 30% because the waters of the
    Elizabeth River have been condemned by the Va. Dept. of Health.

2. From the Va. Dept. of Highways & Transportation.
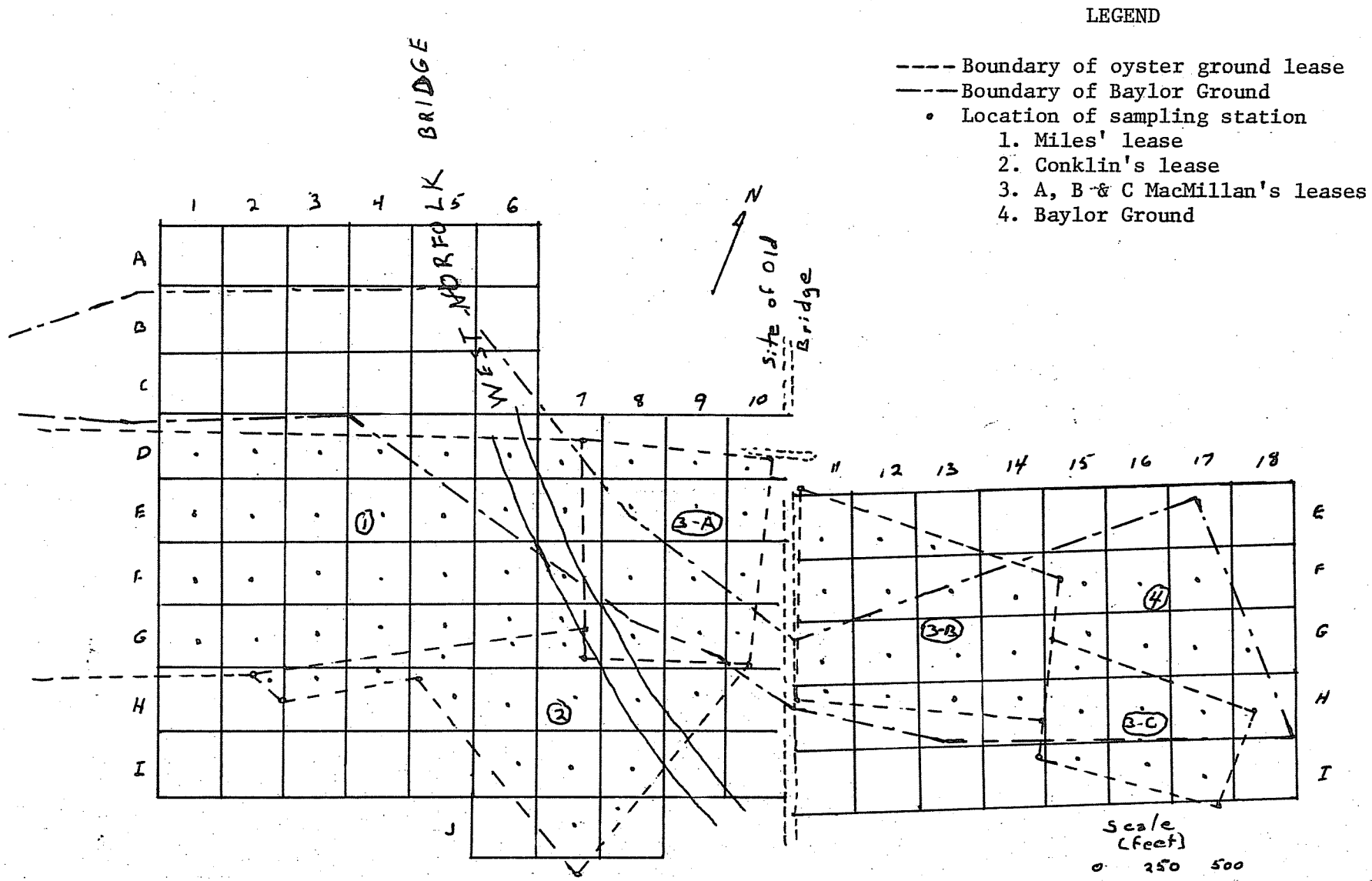
Figure 1. Western Branch of the Elizabeth River in the Vicinity of
   the West Norfolk Bridge - Sampled in June 1979 by VIMS.

APPENDIX

Table A

Results of Sampling Leased Area 1 (J. H. Miles & Co.) Adjacent to the West Norfolk Bridge – 1979.

Station Designation	Bottom Type	Area Covered (sq yd)	LIVE OYSTERS Number Lg	Sm	Tot	Density of Total (No./yd^2)	Number of Spat	BOXES Number	Percent	SHELL Quantity (quarts) Surface	Buried	Total	Density of Total (Qts/yd^2)
D1	F	1.24	6	9	15	12.1	0	1	6	0.1	0.6	0.7	0.6
D2	M	1.24	0	0	0	--	0	5	100	0.1	3.9	4.0	0.2
D3	M	1.24	0	0	0	--	0	0	--	0.0	0.0	0.0	--
D4	M	1.24	0	0	0	--	0	0	--	0.0	2.0	2.0	1.6
D5	F	2.48	10	12	22	8.9	0	3	12	14.0	4.0	18.0	7.2
D6*	H	2.48	1	14	15	6.0	2	12	44	28.0	3.0	31.0	12.5
D7	F	2.48	2	16	18	7.2	0	10	36	12.0	12.0	24.0	9.7
E1	F	1.24	5	11	16	12.9	0	11	41	9.6	2.4	12.0	9.7
E2	F	1.24	2	6	8	6.4	0	5	38	6.3	2.7	9.0	7.2
E3	F	1.24	0	0	0	--	0	3	100	1.5	3.5	5.0	4.0
E4	F	1.24	4	9	13	10.5	0	2	13	9.0	1.0	10.0	8.1
E5	M	1.24	7	19	26	21.0	0	9	26	5.4	0.6	6.0	4.8
E6*	H	2.48	3	13	16	6.4	0	9	36	11.8	4.2	16.0	6.4
E7*	H	2.48	3	20	23	9.3	0	10	30	8.5	5.5	14.0	5.6
F1	F	1.24	2	4	6	4.8	0	6	50	4.4	6.6	11.0	8.9
F2	F	1.24	10	12	22	17.7	0	28	56	15.6	10.4	26.0	21.0
F3	M	1.24	0	0	0	--	0	5	100	0.4	7.6	8.0	6.4
F4	F	1.24	6	9	15	12.1	2	6	28	9.0	9.0	18.0	14.5
F5	F	2.48	5	22	2.7	10.9	0	7	20	19.2	4.8	24.0	9.7
F6	F	2.48	13	13	26	10.5	3	8	24	6.6	4.4	11.0	4.4
F7*	H	2.48	7	21	28	11.3	3	10	26	15.0	3.0	18.0	7.2
G1	F	1.24	1	3	4	3.2	0	6	60	6.0	9.0	15.0	12.1
G2	F	1.24	1	0	1	0.8	0	1	50	6.0	2.0	8.0	6.4
G3	F	1.24	11	20	31	25.0	0	28	47	24.8	6.2	31.0	25.0
G4	M	1.24	0	1	1	0.8	0	5	83	0.2	2.8	3.0	2.4
G5	F	2.48	6	10	16	6.4	0	9	36	7.5	7.5	15.0	6.0
G6	M	1.24	2	2	4	3.2	1	9	69	3.0	9.0	12.0	9.7
G7*	H	1.24	0	13	13	10.5	5	6	32	10.5	3.5	14.0	11.3
Totals		45.88	107	259	366	--	16	211	--	234.5	131.2	365.7	--
Averages for Area						8.0			36				8.0

* These stations were in or next to the right-of-way.

M = soft mud; F = firm mud and sand mixture; H = hard bottom.

Table B

Results of Sampling Leased Area 1 (J. H. Miles & Co.) Adjacent to the West Norfolk Bridge - 1974.

Station Designation	Bottom Type	Area Covered (sq yd)	LIVE OYSTERS Number Lg	Sm	Tot	Density of Total (No./yd²)	Number of Spat	BOXES Number	Percent	SHELL Quantity (quarts) Surface	Buried	Total	Density of Total (Qts/yd²)
D1	M	2.4	0	0	0	--	0	0	0	0.0	5.0	5.0	2.1
D2	M	2.4	0	0	0	--	0	0	0	0.0	3.0	3.0	1.2
D3	M	2.4	6	1	7	2.9	0	0	0	2.8	10.2	13.0	5.4
D4	M	2.4	7	7	14	5.8	0	4	22	16.3	4.7	21.0	8.8
D5	M	2.4	0	0	0	--	0	0	0	0.0	11.0	11.0	4.6
D6*	M	2.4	0	0	0	--	0	1	100	20.6	10.4	31.0	12.9
D7	M	2.4	0	0	0	--	0	0	0	0.0	8.0	8.0	3.3
E1	M	2.4	0	0	0	--	0	0	0	0.0	6.0	6.0	2.5
E2	M	2.4	1	1	2	0.8	0	0	0	5.5	8.5	14.0	5.8
E3	M	2.4	4	1	5	2.1	0	1	17	5.5	9.5	15.0	6.2
E4	M	2.4	10	9	19	7.9	0	10	34	2.5	2.5	5.0	2.1
E5	M	2.4	0	1	1	0.4	0	0	0	0.4	1.6	2.0	0.8
E6*	M	2.4	6	6	12	5.0	0	8	40	5.0	5.0	10.0	4.2
E7*	M	2.4	8	8	16	6.7	0	5	24	9.0	6.0	15.0	6.2
F1	M	2.4	4	1	5	2.1	0	1	17	13.0	17.0	30.0	12.5
F2	M	2.4	6	3	9	3.8	0	4	31	12.6	19.4	32.0	13.3
F3	M	2.4	7	3	10	4.2	0	1	9	9.8	3.2	13.0	5.4
F4	M	2.4	9	13	22	9.2	0	7	24	7.1	8.9	16.0	6.7
F5	M	2.4	4	5	9	3.8	0	1	10	6.3	7.7	14.0	5.8
F6	M	2.4	19	12	31	12.9	0	7	18	17.0	17.0	34.0	14.2
F7*	M	2.4	4	7	11	4.6	0	2	15	12.0	6.0	18.0	7.5
G1	M	2.4	0	0	0	--	0	0	0	0.4	3.6	4.0	1.7
G2	M	2.4	3	5	8	3.3	0	5	38	5.5	5.5	11.0	4.6
G3	M	2.4	9	1	10	4.2	0	3	23	9.5	9.5	19.0	7.9
G4	M	2.4	2	4	6	2.5	0	2	25	4.0	8.0	12.0	5.0
G5	M	2.4	2	1	3	1.2	0	1	25	4.0	4.0	8.0	3.3
G6	M	2.4	1	1	2	0.8	0	1	33	2.8	11.2	14.0	5.8
G7*	M	2.4	3	1	4	1.7	0	1	20	3.6	7.4	11.0	4.6
Totals		67.2	115	91	206	--	0	65	--	175.2	219.8	395.0	--
Averages for Area						3.1			24				5.9

* These stations were in or next to the right-of-way.

M = soft to firm mud bottom.

Table C

Results of Sampling Leased Area 2 (T. H. Conklin) Adjacent to the West Norfolk Bridge - 1979.

Station Designation	Bottom Type	Area Sampled (sq yd)	LIVE OYSTERS Number Lg	Sm	Tot	Density of Total (No./yd²)	Number of Spat	BOXES Number	Percent	SHELL Quantity (quarts) Surface	Buried	Total	Density of Total (Qts/yd²)
G5	M	1.24	0	0	0	--	0	0	0	0.0	0.0	0.0	--
G6	M	1.24	0	0	0	--	0	0	0	0.0	1.0	1.0	0.8
G7*	H	1.24	0	4	4	3.2	1	2	33	3.6	0.4	4.0	3.2
H2	M	1.24	0	0	0	--	0	0	0	0.1	0.9	1.0	0.8
H3	M	1.24	0	0	0	--	0	0	0	0.0	0.0	0.0	--
H4	M	1.24	0	0	0	--	0	0	0	0.0	0.0	0.0	--
H5	M	1.24	1	0	1	0.8	0	0	0	1.7	3.3	5.0	4.0
H6	M	2.48	0	2	2	0.8	2	3	60	2.2	2.8	5.0	2.0
H7	F	2.48	3	14	17	6.8	0	8	32	27.4	8.6	36.0	14.5
H8*	M	2.48	4	4	8	3.2	0	5	38	4.0	12.0	16.0	6.4
H9	M	2.48	5	5	10	4.0	1	5	33	3.0	3.0	6.0	2.4
I6	M	1.24	0	0	0	--	0	0	0	0.0	0.0	0.0	--
I7	M	2.48	0	0	0	--	0	0	0	0.0	0.0	0.0	--
I8	F	2.48	0	4	4	1.6	0	9	69	8.8	16.2	25.0	10.0
J7	M	2.48	0	0	0	--	0	0	0	0.0	0.0	0.0	--
J8	M	1.24	0	0	0	--	0	0	0	0.0	0.0	0.0	--
Totals		28.52	13	33	46	--	4	32	--	50.8	48.2	99.0	--
Averages for Area						1.5			41				3.5

* These stations were in or next to the right-of-way.

M = soft mud; F = firm mud and sand mixture; H = hard bottom.

Table D

Results of Sampling Leased Area 2 (T. H. Conklin) Adjacent to the West Norfolk Bridge – 1974.

Station Designation	Bottom Type	Area Covered (sq yd)	LIVE OYSTERS Number Lg	Sm	Tot	Density of Total (No./yd^2)	Number of Spat	BOXES Number	Percent	SHELL Quantity (quarts) Surface	Buried	Total	Density of Total (Qts/yd^2)
G5	M	2.4	2	0	2	0.8	0	0	0	0.3	2.7 --	3.0	1.2
G6	M	2.4	4	3	7	2.9	0	1	12	2.5	2.5	5.0	2.1
G7*	M	2.4	0	0	0	--	0	0	0	3.0	3.0	6.0	2.5
H2	M	2.4	0	0	0	--	0	0	0	0.0	7.0	7.0	2.9
H3	M	2.4	3	6	9	3.8	0	2	18	5.4	3.6	9.0	3.8
H4	M	2.4	0	0	0	--	0	0	0	0.0	3.0	3.0	1.2
H5	M	2.4	0	0	0	--	0	0	0	0.0	3.0	3.0	1.2
H6	M	2.4	0	0	0	--	0	0	0	0.0	2.0	2.0	0.8
H7	M	2.4	4	3	7	2.9	0	0	0	3.0	2.0	5.0	2.1
H8*	M	2.4	1	0	1	0.4	0	0	0	1.5	1.5	3.0	1.2
H9	M	2.4	1	0	1	0.4	0	0	0	0.3	0.7	1.0	0.4
I6	M	2.4	4	4	8	3.3	0	8	50	1.0	2.0	3.0	1.2
I7	M	2.4	0	0	0	--	0	0	0	0.0	3.0	3.0	1.2
I8	M	2.4	0	0	0	--	0	0	0	0.0	2.0	2.0	0.8
J7	M	2.4	0	0	0	--	0	0	0	0.0	5.0	5.0	2.1
J8	M	2.4	0	0	0	--	0	0	0	0.0	1.0	1.0	0.4
Totals		28.4	19	16	35	--	0	11	--	17.0	44.0	61.0	--
Averages for Area						0.9			24				1.6

* These stations were in or next to the right-of-way.

M = soft to firm mud.

Table E

Results of Sampling Leased Areas 3-A, 3-B & 3-C (R. R. MacMillan) Adjacent to the West Norfolk Bridge - 1979.

Station Designation	Bottom Type	Area Covered (sq yd)	LIVE OYSTERS Number Lg	Sm	Tot	Density of Total (No./yd^2)	Number of Spat	BOXES Number	Percent	SHELL Quantity (quarts) Surface	Buried	Total	Density of Total (Qts/yd^2)
AREA 3-A													
D 8	F	2.48	12	44	56	22.6	7	31	36	23.2	4.8	28.0	11.3
D 9	F	2.48	3	8	11	4.4	0	5	31	9.4	3.6	13.0	5.2
D10	F	1.24	7	13	20	16.1	2	10	33	3.5	3.5	7.0	5.6
E 8	F	2.48	10	41	51	20.6	5	21	29	14.7	7.3	22.0	8.9
E 9	F	2.48	4	35	39	15.7	4	16	29	17.8	4.2	22.0	8.9
E10	F	4.96	11	43	54	10.9	10	2	4	23.6	12.4	36.0	7.2
F 8	F	2.48	6	8	14	5.6	1	2	12	13.2	14.8	28.0	11.3
F 9	M, C	2.48	12	25	37	14.9	2	28	43	29.2	12.8	42.0	16.9
F10	F	4.96	39	81	120	24.2	15	32	21	20.0	18.0	38.0	7.7
G 8*	H	2.48	9	58	67	27.0	12	27	29	20.9	1.1	22.0	8.9
G 9	F	2.48	12	27	39	15.7	1	8	17	11.3	1.2	12.5	5.0
G10	H	2.48	41	60	101	40.7	2	33	25	35.3	5.7	41.0	16.5
Totals		33.48	166	443	609	--	61	215	--	222.1	89.4	311.5	--
Averages for Area						18.2			26				9.3
AREA 3-B													
E11!	F	2.48	4	19	23	9.3	2	7	23	1.8	3.2	5.0	2.0
E12	F	1.24	5	12	17	13.7	5	1	6	2.7	1.3	4.0	3.2
E13	F	1.24	8	21	29	23.4	1	8	22	3.6	0.4	4.0	3.2
F11!	F	2.48	8	11	19	7.7	0	15	44	5.7	5.8	11.5	4.6
F12	F	2.48	13	61	74	29.8	6	21	22	13.6	3.4	17.0	6.8
F13	F	4.96	16	27	43	8.7	1	15	26	6.2	12.8	19.0	3.8
F14	F	4.96	29	44	73	14.7	1	31	30	10.7	12.3	23.0	4.6
G11!	M	4.96	2	1	3	0.6	1	1	25	4.3	8.7	13.0	2.6
G12	M	4.96	5	2	7	1.4	0	0	0	2.5	2.5	5.0	1.0
G13	M	4.96	0	0	0	--	0	0	0	0.0	3.0	3.0	0.6
G14	M	4.96	0	0	0	--	0	0	0	0.0	0.0	0.0	--

Table E (Contd.)

Station Designation	Bottom Type	Area Covered (sq yd)	LIVE OYSTERS					BOXES		SHELL			
			Number			Density of Total ($No./yd^2$)	Number of Spat	Number	Percent	Quantity (quarts)			Density of Total (Qts/yd^2)
			Lg	Sm	Tot					Surface	Buried	Total	
H11!	M	2.48	0	0	0	--	0	1	100	1.2	2.3	3.5	1.4
H12	M	2.48	0	0	0	--	0	0	0	0.0	0.0	0.0	--
H13	M	2.48	0	0	0	--	0	0	0	0.0	0.0	0.0	--
H14	M	4.96	0	0	0	--	0	0	0	0.0	0.0	0.0	--
Totals[1]		39.68	76	167	243	--	14	76	--	39.3	35.7	75.0	--
Averages for Area						6.1			24				1.9
Totals for all 1979 samples		52.08	90	198	288	--	17	100	--	52.3	55.7	108.0	--
Averages for Area						5.5			26				2.1
AREA 3-C													
G15	M	2.48	0	0	0	--	0	0	0	0.0	0.0	0.0	--
H15	M	4.96	0	0	0	--	0	0	0	0.0	0.0	0.0	--
H16	M	4.96	4	8	12	2.4	0	4	25	0.1	0.3	0.4	0.1
H17	M	4.96	1	1	2	0.4	0	5	71	0.0	6.0	6.0	1.2
I15	M	1.24	0	0	0	--	0	0	0	0.0	0.0	0.0	--
I16	M	2.48	0	0	0	--	0	0	0	0.0	0.0	0.0	--
I17	F	2.48	9	16	25	10.1	5	10	28	1.6	3.4	5.0	2.0
Totals		23.56	14	25	39	--	5	19	--	1.7	9.7	11.4	--
Averages for Area						1.6			33				0.5

* This station was next to the right-of-way.

! These stations, which were close to the old bridge, were not done in 1974 because of their proximity to buried utility lines.

M = soft mud; C = clay; F = firm mud and sand mixture; H = hard bottom.

1 These totals and averages are for only those stations which were also sampled in 1974.

Table F

Results of Sampling Leased Areas 3-A, 3-B & 3-C (R. R. MacMillan) Adjacent to the West Norfolk Bridge - 1974.

Station Designation	Bottom Type	Area Covered (Sq yd)	LIVE OYSTERS Number Lg	Sm	Tot	Density of Total (No./yd^2)	Number of Spat	BOXES Number	Percent	SHELL Quantity (quarts) Surface	Buried	Total	Density of Total (Qts/yd^2)
AREA 3-A													
D 8	M	2.4	3	1	4	1.7	0	1	20	7.4	3.6	11.0	4.6
D 9	M	2.4	1	0	1	0.4	0	0	0	1.8	17.2	19.0	7.9
D10	M	2.4	1	0	1	0.4	0	0	0	0.0	12.0	12.0	5.0
E 8	M	2.4	2	8	10	4.2	0	7	41	16.2	1.8	18.0	7.5
E 9	M	2.4	8	9	17	7.1	0	9	35	6.5	6.5	13.0	10.8
E10	M	2.4	0	1	1	0.4	0	1	50	3.5	3.5	7.0	2.9
F 8	M	2.4	7	3	10	4.2	0	2	17	22.0	10.0	32.0	13.3
F 9	M	2.4	0	0	0	--	0	0	0	0.0	9.0	9.0	3.8
F10	M	2.4	0	0	0	--	0	0	0	0.0	3.0	3.0	1.2
G 8*	M	2.4	3	3	6	2.5	0	3	33	2.7	7.3	10.0	4.2
G 9	M, C	2.4	4	5	9	3.8	0	0	10	5.5	9.5	15.0	6.2
G10	M, C	2.4	10	8	18	7.5	0	2	10	5.0	10.0	15.0	12.5
Totals		28.8	39	38	77	--	0	25	--	70.6	93.4	164.0	--
Averages for Area						2.7			24				5.7
AREA 3-B													
E12	M, C	2.4	0	0	0	--	0	0	0	0.0	1.0	1.0	0.8
E13	M	2.4	0	5	5	2.1	0	0	0	2.7	1.3	4.0	3.3
F12	M	2.4	1	2	3	1.2	0	2	40	2.5	2.5	5.0	4.2
F13	M	2.4	0	1	1	0.4	0	0	0	3.0	3.0	6.0	5.0
F14	M	2.4	2	6	8	3.3	0	2	20	5.0	5.0	10.0	4.2
G12	M	2.4	0	0	0	--	0	0	0	0.0	0.5	0.5	0.4
G13	M	2.4	0	0	0	--	0	0	0	0.0	0.5	0.5	0.4
G14	M	2.4	0	0	0	--	0	0	0	0.0	0.5	0.5	0.4
H12	M	2.4	0	0	0	--	0	0	0	0.0	0.2	0.2	0.1
H13	M	2.4	0	0	0	--	0	0	0	0.0	0.0	0.0	--
H14	M	2.4	0	0	0	--	0	0	0	0.0	0.0	0.0	--

Table F (Contd.)

			LIVE OYSTERS					BOXES		SHELL			
		Area	Number			Density	Number	Number	Percent	Quantity (quarts)			Density
Station Designation	Bottom Type	Covered (Sq yd)	Lg	Sm	Tot	of Total (No./yd^2)	of Spat			Surface	Buried	Total	of Total (Qts/yd^2)
Totals		26.4	3	14	17	--	0	4	--	13.2	14.5	27.7	--
Averages for Area						0.6			19				1.0
AREA 3-C													
G15	M	2.4	0	0	0	--	0	0	0	0.0	0.0	0.0	--
H15	M	2.4	0	0	0	--	0	0	0	0.0	3.0	3.0	1.2
H16	M	4.8	0	0	0	--	0	0	0	0.0	6.5	6.5	1.4
H17	M	4.8	18	14	32	6.7	0	4	11	9.0	10.0	19.0	4.0
I15	M	2.4	0	0	0	--	0	0	0	0.0	0.5	0.5	0.2
I16	M	2.4	16	12	28	11.7	0	11	28	10.0	10.0	20.0	8.3
I17	M	2.4	0	0	0	--	0	0	0	0.0	3.0	3.0	1.2
Totals		21.6	34	26	60	--	0	15	--	19.0	33.5	52.5	--
Averages for Area						2.8			20				2.4

* This station was next to the right-of-way.

M = soft to firm mud; C = clay.

Table G

Results of Sampling a Portion of Baylor Bottom Below the West Norfolk Bridge in Both Years.

Station Designation	Bottom Type	Area Covered (Sq yd)	Lg	Sm	Tot	Density of Total (No./yd^2)	Number of Spat	Number	Percent	Surface	Buried	Total	Density of Total (Qts/yd^2)
			Number					BOXES		Quantity (quarts)			
1979													
F15	M	2.48	27	36	63	25.4	1	15	19	N/A	N/A	8.0	3.2
F16	M	4.96	15	22	37	7.4	2	3	8	N/A	N/A	6.0	1.2
F17	M	4.96	32	22	54	10.9	6	7	11	N/A	N/A	13.5	2.7
G15	M	2.48	10	8	18	7.2	0	3	14	N/A	N/A	6.0	2.4
G16	M	4.96	14	8	22	4.4	2	10	31	N/A	N/A	8.0	1.6
G17	M	4.96	5	5	10	2.0	0	2	17	3.3	4.7	8.0	1.6
G18	M	4.96	12	28	40	8.1	5	8	17	1.4	2.1	3.5	0.7
Totals		29.8	115	129	244	---	16	48	---	N/A	N/A	53.0	---
Averages for Area						8.2			16				1.8
1974													
E16!	M	2.4	0	0	0	---	0	0	0	0.0	0.3	0.3	0.2
E17!	M, C	2.4	0	0	0	---	0	1	100	0.2	0.8	1.0	0.4
F15	M	2.4	0	0	0	---	0	0	0	3.0	1.0	4.0	3.3
F16	M	2.4	0	0	0	---	0	0	0	0.0	3.0	3.0	2.5
F17	M	2.4	0	0	0	---	0	0	0	0.2	0.8	1.0	0.4
G15	M	2.4	1	1	2	0.8	0	0	0	0.0	4.0	4.0	1.7
G16	M	2.4	4	6	10	4.2	0	3	23	7.4	3.6	11.0	4.6
G17	M	2.4	0	0	0	---	0	0	0	1.0	1.0	2.0	0.8
G18	M	2.4	3	0	3	1.2	0	1	25	2.4	3.6	6.0	5.0
H18!	M	2.4	0	0	0	---	0	0	0	0.0	4.0	4.0	3.3
Totals[1]		16.8	8	7	15	---	0	4	---	14.0	17.0	31.0	---
Averages for Area						0.9			21				1.8
Totals[1] for all 1974 samples		24.0	8	7	15	---	0	5	---	14.2	22.1	36.3	---
Averages for Area						0.6			25				1.5

! These stations were not repeated in 1979.

[1] These totals and averages are for only those 1974 stations which were repeated in 1979.

N/A Data are not available.

M = soft mud; C = clay.